Deep Terrestrial Heat-Flow Studies in Southwestern United States

Deep geothermal gradient measurements yielding good heat-flow data are necessary to accurately predict lithospheric and asthenospheric temperatures and relate thermal conditions in the lithosphere and asthenosphere to fundamental tectonic processes such as vertical movements in the earth. Many heat-flow measurements are calculated from temperature gradients taken at depths less than 1 km. In some places, groundwater perturbation of these temperature gradients precludes basic appreciation of regional lithospheric or local geothermal conditions. Previous heat-flow data suggest the Colorado Plateau is an area of low heat flow (~1.2 HFU) whereas new deeper heat-flow measurements show the Colorado Plateau has intermediate heat flow (~1.6 HFU). These new data are in keeping with other geophysical measurements. As such, the gradual uplift component of vertical movement over the western United States since the Eocene may relate to lithospheric reheating (thermal expansion) as North America drifted over hotter asthenosphere. New deep data in the southern Basin and Range province indicate regional heat flow of 1.95 HFU suggesting 0.3 to 0.4 HFU difference between the Basin and Range and Colorado Plateau. Different lithospheric responses to asthenospheric anomalies may allow widespread magma intrusion in the Basin and Range with only modest intrusion in the Colorado Plateau. Both large scale and local geothermal anomalies are also significantly perturbed by groundwater movement, e.g., the Rio Grande rift and the San Francisco Mountains. High quality heat-flow data extending along profiles from mountainous areas will allow appreciation of thermal conditions in mountain blocks and magma bodies, such as profiles from the southern Rockies and the San Juan Mountains.

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Conodont Animal—Hypotheses and Speculations

More than a century after their discovery, conodonts remain biologic orphans. These skeletal constituents of some as yet unspecified marine organisms have been assigned by various workers to: vertebrates (from ancestral to advanced), arthropods, several kinds of worms, several classes of mollusks, lophophorates, separate classes (or a phylum) all their own, and even algae and vascular plants. Functional interpretations of conodonts include: stem, gill, or tentacular supports; dermal spines and scales; radulae; digestive tract stirrers and sieves; jaws, teeth, or "superteeth;" and copulatory graspers. Each conodontophorid bore up to at least two dozen, commonly very differently shaped, conodont elements in an apparatus. The existence and makeup of these multi-element apparatuses are known from naturally occurring assemblages of elements that are interpreted as coprolitic, gut contents, in-situ burials, fused clusters, or empirical reconstructions based on numerical (clustering) techniques.

Current hypotheses about the form and function of the apparatuses, and hence the nature of the organism itself, center on whether some elements functioned as fused units for grasping or as members of an array of food-gathering and/or sieving digits and pectinate units, possibly in a lophophore. Bearing on these hypotheses are the questions. (1) Were all conodont elements always enveloped by soft tissue during life? (2) Do the fused clusters owe their fusion to biologic processes or to postmortem diagenetic mineralization? The question of biological affinity remains unresolved. However, recently discovered fused clusters suggest that fusion was diagenetic.

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History of Sulfidization of South Texas Roll-Type Uranium Deposit

Studies of the mineralogy, sulfur isotope geochemistry, and uranium-lead isotope geochronology of a roll-type orebody in the Felder deposit, south Texas, have indicated important constraints on the genesis of this deposit. Post-mineralization sulfidization of the host Oakville Sandstone (Miocene) resulted in precipitation of pyrite and marcasite in the altered tongue that differ in relative abundance and in isotopic composition from pyrite and marcasite elsewhere in the host rock. The altered tongue is characterized by a predominance of pyrite over marcasite and by heavy $\delta^{34}S$ values (−5.2 to +20.6 per mil), whereas reduced-barren and mineralized rock is characterized by abundant ore-stage marcasite and by light $\delta^{34}S$ values (−29.9 to −47.7 per mil). In reduced-barren and mineralized rock, two generations of pyrite are present: (1) pre-ore pyrite grains that are commonly enclosed by ore-stage marcasite; and (2) post-ore pyrite that is genetically equivalent to pyrite in the altered tongue. Resulfidization of the deposit by hydrogen sulfide-bearing solutions introduced along one or more nearby faults is indicated by the similarity in isotopic compositions of pyrite in the altered tongue to that of sour gas in the underlying Edwards Limestone (Cretaceous). The time of this resulfidization is probably indicated by the unusually precise $^{207}Pb/^{204}Pb$–$^{235}U/^{204}Pb$ isochron age of 5.09 ± 0.11 m.y. The lack of significant scatter of the points on the isochron diagram must reflect the immobility of uranium and lead over the last 5 m.y. due to the continued presence of hydrogen sulfide. The 5-m.y. isochron age indicates that no significant roll-forming processes have occurred in the Felder deposit since this time.

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Upper Cretaceous Mosby Sandstone, Central Montana—Example of Thin, Widespread Storm-Generated Sandstone Cycles

The Mosby Sandstone Member of the Greenhorn Formation is composed of thin (less than 6 ft or 1.8 m), very fine-grained to fine-grained sandstone cycles separated by shale. The sandstones occur either as individual beds, generally less than 1 ft (9.3 m) thick and separated by interbeds of shale, or as amalgamated beds. The base of each cycle is a planar to undulating erosional surface, and the top is gradational with the overlying shale. The dominant sedimentary structures are parallel lamination and low-angle cross-lamination filling broad, shallow troughs. Wave-ripple cross-lamination and wave ripples are commonly developed in the upper parts of the cycles. Trace fossils are generally restricted to the rippled surfaces and consist of horizontal *Ophiomorpha* and *Thalassinoides, Diplocraterion*, and *Chondrites*. Shells, including gastropods, bivalves, and ammonites, occur as lenses near the base of the cycles and as concretions laterally where the sandstones are not developed.

The thin sandstone cycles occur as elongate bodies that are a few tens of miles across and several tens of miles long. The bodies collectively occur in a southward-projecting lobe that covers an area of 40,000 sq mi (64,372 sq km) in central Montana. The sediments were transported as much as 700 mi (1,127 km) in a southeastward direction from the Dunvegan delta in northwestern Alberta. The sandstone cycles are interpreted to have been deposited by storm events on a broad shallow shelf. The sand was probably transported by intense wave action and storm-generated currents and deposited after erosion during the waning stages of the storm.

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Development of Biogenic Gas from Shallow, Low-Permeability Reservoirs—Examples from Southeastern Alberta and Bowdoin Dome Area, North-Central Montana

Prior to 1970, shallow gas production was established in "sweet spots" where the reservoirs are best developed in the northern Great Plains. Recent advances in completion technology coupled with higher gas prices have led to the expansion of these areas through the development of submarginal, low-permeability reservoirs. The development is concentrated in two main areas which cover more than 22,000 sq km. The gas occurs at depths less than 600 m, and recoverable reserves average 2 Bcf of gas per section.

The reservoirs are of Late Cretaceous age and generally consist of siltstone and sandstone laminae, a few millimeters or less in thickness, enclosed in organic-rich silty shale that serves as a seal and was the source for the biogenic gas. The laminae are discontinuous because of depositional processes and/or biologic activity. Coarsening-upward sandstone cycles are locally developed. Although these cycles display the best reservoir properties, they are volumetrically minor. Porosity is confined to small passageways within the laminae, among randomly oriented allogenic clay platelets, and to well-sorted sandstone near the top of coarsening-upward cycles. Diagenesis has reduced permeability and resulted in the formation of fluid-sensitive clays and carbonate cement. However, dissolution has enhanced porosity and permeability in well-sorted lithologies.

The reservoirs are stimulated with sand proppant, carbon dioxide, and water to provide economic flow rates. Typical wells have initial potentials of 300 Mcf of gas per day. Production declines rapidly the first year, but levels off to about 100 Mcf of gas per day. Wells are difficult to evaluate because conventional logs cannot distinguish pay zones in sequences of thin, discontinuous, low-permeability reservoirs.

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Low-Cost Microprocessor System for Paleontologic Information, Including Images

A major problem with paleontologic information is that the names by which fossils are recorded tend to change in meaning over the years, and to be applied differently by different authors. This prevents the growth of an enduring, reliable data base for biostratigraphic and paleoenvironmental interpretations. We are using the storage and sorting capabilities of a microcomputer to supplement Linnaean names with a searchable system of morphologic descriptors. A problem with systems of descriptors is that they can convey only a very limited fraction of the information about the shape of a fossil. Our microcomputer system, therefore, has the capability of storing a low-resolution image together with the set of verbal and numeric descriptors of each form.

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Location of Littoral Energy Fence and Resolution of Relict Features on Atlantic Shelf, United States—Fourier Grain Shape Analysis

Even though, in any given area, shelf sands deposited during the Holocene-Pleistocene may have a common provenance, sands deposited during the latest transgression can be distinguished from sands delivered earlier, by using Fourier Grain Shape Analysis. Sands with longer residence times on the Long Island shelf have smooth abraded grain profiles whereas the youngest sand tends to be much more irregularly shaped. In the nearshore zone, the percentage of irregular grains grades rapidly from approximately 100% at the beachface to 70% at the 10 m depth. Seaward of the 10-m isobath, the proportion of irregular sand decreases at a much slower rate. This change in gradient defines a boundary between nearshore sands and more abraded sands of the middle and outer shelves where little onshore-offshore mixing of sediments occurs. This boundary, the littoral energy fence, also has been seen on the South Carolina shelf.

Sands on the Long Island middle and outer shelf are characterized by relatively high percentages of highly abraded sand. Samples from this zone show areas with slightly higher (80 to 100%) or lower (50 to 80%) proportions of abraded quartz. This pattern appears to be related to morphologic elements on the shelf. In contrast, the South Carolina middle and outer shelf contains broad, coast-perpendicular stripes of abraded sand alternating with stripes from 10 to 30 km wide that are strongly dominated by first-generation irregular sand. Stripes containing high proportions (over 75%) of irregular sands are interpreted to be understories of alluvial valleys of the ancestral Cooper, Santee, and Waccamaw Rivers.

These results indicate that shelf sediments preserve a